MOTOROLA

Date [redacted]

To: Kevin Jelley [redacted]

From: Zili Li

Subject: Power View: Reflective Displays that generate power for portables

Executive Summary

An innovation combining the display technology with solar panel to generate power for portable products has been evaluated and demonstrated. The basic idea is to hide a solar cell behind a reflective display to covert the ambient light into electric power. In particular, we have studied the case of a cholesteric liquid crystal display (Ch-LCD)/Solar cell combination because Ch-LCD's large transmission of ambient light. One critical requirement for realization of this approach is that no optical performance degradation will be resulted as we introduce this combination. We have identified two solar panels with performance similar or better to the black absorption layer currently in use. Ch-LCD with such a solar cell as a back absorber and conventional Ch-LCd with black paint as the back absorber have been fabricated and they respective optical performance has been measured and compared. Display characterization shows good contrast and visual appearance will be maintained. Power measurements are carried out to characterize such a display/power source system. [redacted]

[redacted]

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MOTOROLA PATENT COMMITTEE

Disclosure	Date
13651	[redacted]
Division	Corp manuf.
Patent Committee	Mfg. Sci

Disclosure for Patent Committee Review
Submitted Pursuant to Employee Agreement

DISCLOSURE TYPE:

SHORT FORM	X	When using the short form (single page), the review committee may request additional information before reaching a decision.
EXPANDED FORM		Use additional pages in the expanded form if you feel more information will be necessary for the committee to reach a decision.

1. **Title of Invention:** Reflective Liquid Crystal Displays with Photo-voltaic Element as the Replacement for back Absorber

1a. Key Words: Cholesteric LCD, PDLC, solar cells, back absorber

2. **Primary or contact point inventor(s)** *Use your full first, middle, and last names. Use page 2 of the expanded disclosure form for contributing inventors.*

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Citizenship	SSN	Street	City	State	Zip
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3. **What was the problem(s) to be solved by the invention or what was the need(s) for the invention:**

Portable products, such as cellular phones, PDA and pagers, that use low battery energy are of great interest for Motorola. One way to extend battery life is to increase the energy supply. An alternative method is to reduce the power consumption. This invention addresses the third approach: utilization of otherwise wasted light (solar) energy, converting it to electric energy as a supplemental source through the proper combination of display in use and the solar cell.

4. **What is the prior art, and why doesn't it resolve the problem(s) or fulfill the need(s):**

The use of solar cells as a power source on low power portable devices is well known, such as in the case of the pocketsize calculator. In prior art, the light collecting surface of the solar cell and the display are placed side by side. Two recent patents (in 1996) have been found that the display and the solar cell are in stacked arrangement. The first is a transmissive type LCD that uses an always-on backlight as its illumination. The other is a reflective type of display using a hologram reflector as a replacement for a conventional reflector. [redacted]

[redacted]

5. **What is the invention being disclosed:**

This invention consists of reflective (monochrome or color) liquid crystal display that does not require a separated reflective element such as various reflectors; and a solar cell in a tandem (stacked) arrangement. In this invention, the solar cell is placed immediately behind the liquid crystal cell. The display itself does not require a separate reflector; in other word, there will be no other reflective component between the back of the LC cell and the front of the solar cell. The absence of the reflector will insure that large percentage of incoming ambient light will pass through the display and impinge upon on the solar cell to increase the usefulness of the solar cell as a supplemental energy source. In particular, this combination can be applied to choelsteric liquid crystal display or Polymer Dispersed Liquid Crystal Display; both are free of reflector, by replacing the back absorber in the prior art with a solar cell.

6. **How does this invention resolve the problem(s) and fulfill the need(s) in a new way: Attach** *any drawings or diagrams you feel are necessary for clarification.*

Reflective liquid crystal displays on the market use a separate reflector to redirect the incoming ambient light to human eyes to form visual image. This reflector in combination with other lossy elements in the current structure such as color filter and polarizer cuts the light level after the reflector to a negligible amount (~ 1%) for any meaningful reuse of that part of the light energy. On the other hand, for the display technologies that do not require the back reflector, such as cholesteric and PDLC, a substantial amount (> 75% in some cases) light will pass the display. A black absorber has to be placed on the rear surface of the display to collect this passed light energy for the quality image. By replacing this absorber with a solar cell, based on our model, a sizable energy as compared with the standard LiH battery can be collected. Depending on user model, electrical energy in the range of 20 – 40 % of the total StarTac battery energy has been shown by our model for single color cholesteric liquid crystal display, on the contrary, less than 2 % could be collected if using the display with a reflector.

7. **Date of Conception:** [redacted] **and if applicable, date first built (or written) and successfully tested:** [redacted]

8. **Product(s) this invention may be used in:** [redacted]

9. **Date the first offer for sale was made for a product incorporating this invention:** N/A

10. **Date the first disclosure of this invention was made outside Motorola without a nondisclosure agreement:** N/A

11. **Approvals:** *1)* Technical Staff or Patent Liaison; *2)* Management (both required). Signing this form attests to the fact that you understand the invention.

	Name / Signature	Dept. No.	Location/Room #	Phone Number
1)				
2)				

12. **Witnesses:**

Witness: _____ Date: _____ Witness: _____ Date: _____

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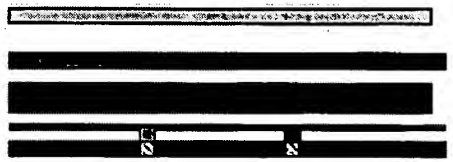
Prior Art

Side by Side

Stacked



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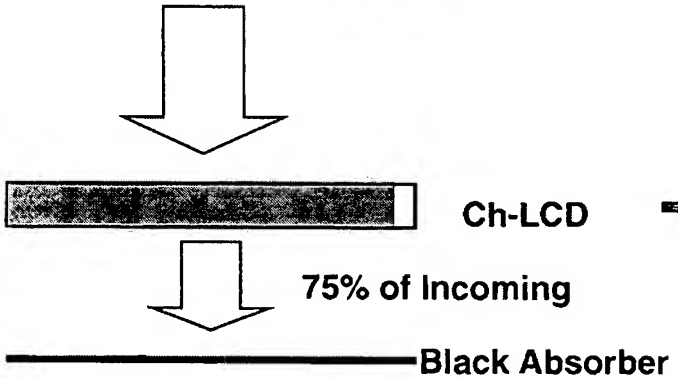
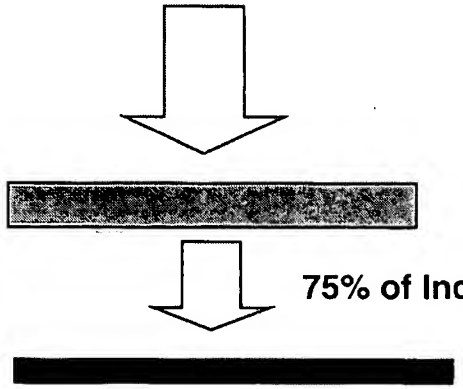
Solar cell location

This Invention





MATC Display Technologies Lab.

Solar cell behind Reflectice LCD panel as supplemental energy source

	Solar Cell1(A52,169)	Solar Cell2(A35,437)	Solar Cell3(A37,339)
Solar Cell Parameters	[redacted]	[redacted]	[redacted]
Full Sun	10 V	20 V	0.5 V
	9 mA	250 mA	250 mA
	90 mW	5000 mW	125 mW
Indoor Light	0.603 mW	33.5 mW	0.8375 mW
Panel Size	1.5 in L	7 in L	0.79 in L
	2.5 in W	8 in W	1.57 in W
Panel Area	3.75 sq.in.	56 sq.in.	1.2403 sq.in.
Thickness	1.6 mm	6.35 mm with frame	0.2 mm
Weight		1.2 gram/sq.in.	
$/sq.in retail	[redacted]	[redacted]	[redacted]
Power Output/sq.in			
TN or STN	0.05		
Ch-LCD			
mono or ETC	0.74		
Full sun	17.76 mW/sq.in	66.07143 mW/sq.in	74.57873 mW/sq.in
Indoor Light	0.118992 mW/sq.in	0.442679 mW/sq.in	0.499677 mW/sq.in
Energy Generation			
Use Model 1: Typical user, MAP 5.2 sq.in	5.2		
0.2 full sun ?			
Out dr/day 2 hour	132.9869 J	494.7429 J	558.4455 J
Indoor/day 10 hour	22.2753 J	82.86943 J	93.53963 J
Bat. Life 3 day			
Total	465.7865 J	1732.837 J	1955.955 J
[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]
TN or STN	0.511242 %	1.901942 %	2.146835 %
Use Model 2: On the road, MAP 5.2 sq.in	5.2		
0.2 full sun ?			
Out dr/day 4 hour	265.9738 J	989.4857 J	1116.891 J
Indoor/day 15 hour	33.41295 J	124.3041 J	140.3094 J
Bat. Life 2 day			
Total	598.7734 J	2227.58 J	2514.401 J
[redacted]	[redacted]	[redacted]	[redacted]
[redacted]	[redacted]	[redacted]	[redacted]
TN or STN	[redacted]	[redacted]	[redacted]

[redacted]

	by weight		*by cost*	
	Use model 1	Use model 2	Use model 1	Use model 2
Solar cell	277.6982 J/g	356.9839 J/g	116.6697 J/$	149.9801 J/$
Extended battery	165.0402 J/g	165.0402 J/g	61.56 J/$	165.0402 J/$

Note:

a) StarTac battery life: [redacted]

b) Power consuptions

	Standby		Active	
MAP	[redacted]	[redacted]	[redacted]	[redacted]
StarTac	[redacted]	[redacted]	[redacted]	[redacted]

c) StaTac Battery price

	Whole sale	Retail
Standard	[redacted]	[redacted]
Extended	[redacted]	[redacted]

d) StarTac battery weight Basic: 37.3 grams w/o case
44.9 grams with case

e) Power conversion from full sun to indoor based on the A52,162 at 150x

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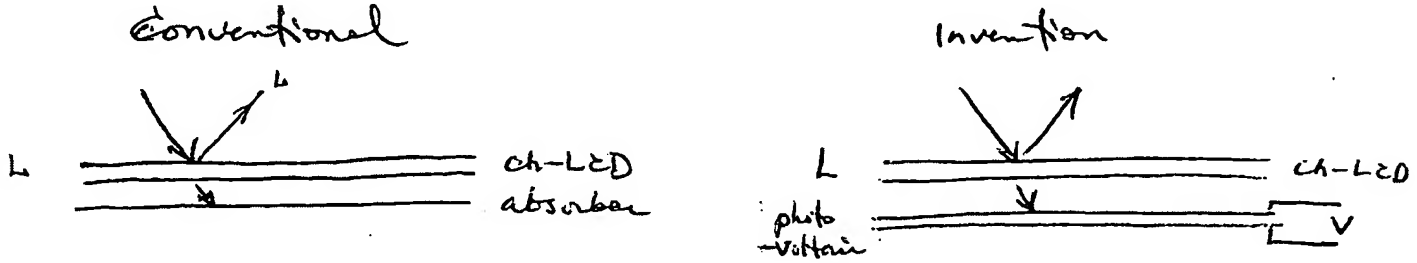
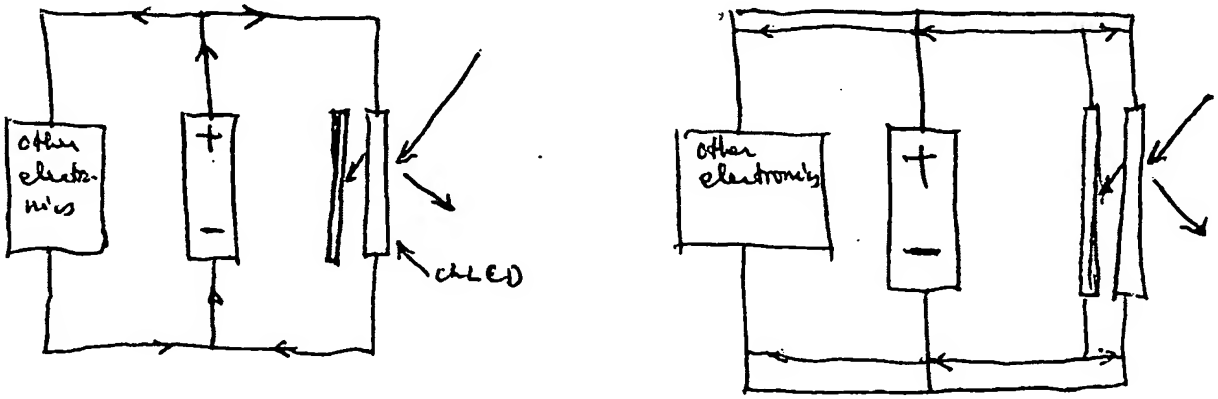
TITLE	MODEL
Cholesteric LCD with Photo-voltaic Element As Back Absorber.	

Problem: The choloesteric LCD use selective reflection in stead of absorption At least 50% incoming light ~~passed~~ passes the display & this portion of light is being absorbed by a ~~an~~ absorber affixed to the back of ch-LCD.

Solution: This invention is consists of a new structure in which the conventional lossy absorber is replaced by a Photo-voltaic element. The element will convert the otherwise being absorbed → heat ~~energy~~ light energy to electrical energy that can be used as power supply for the portable product.



For portable product such as pager or cellphone. This can be a supplementary source for power



WRITER	DATE	WITNESS	DATE
[redacted]	[redacted]	[redacted]	[redacted]